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## THE LOCAL DISTRIBUTION OF INTRODUCED SPECIES NEAR DOUGLAS LAKE, MICHIGAN\*

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During the summer of 1914 Gleason and McFarland made a study of the local distribution of introduced species of phanerogams in the vicinity of the biological station of the University of Michigan.† It was then shown that less than half of the introduced species had succeeded in establishing themselves in the uncultivated region in the vicinity of the biological station and that their number steadily decreased with increasing distance from civilization; that these introduced species were in many cases dependent upon human aid for their dispersal; and that they were unable to compete successfully with the native vegetation.

During the summer of 1917 these observations were continued and in part repeated, in many instances in precisely the same localities. The general conclusions of the earlier paper, as stated above, are fully confirmed, while successive study of the same area after a three-year interval has given opportunity to show the present course of development in the introduced vegetation and among the introduced species.

### I. THE INTRODUCED FLORA OF SUMMER RESORTS

The reduction in the number of introduced species with increasing distance from agriculture or permanent residences is

\* Publication no. 171 from the Botanical Department of the University of Michigan.

† H. A. Gleason and F. T. McFarland, The introduced vegetation in the vicinity of Douglas Lake, Michigan. Bull. Torr. Club 41: 511-521. 1914.

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still apparent. On the north shore of Douglas Lake, three long-established summer-resort colonies, separated by half-mile intervals, showed in 1914 a reduction in number of species from 42 to 26 and 1. These proportions are still maintained, although with some changes, in the species represented. On the same shore of the lake, half a mile farther from permanent residences, a cottage was built in 1916. Although the forest has been cleared around it, affording better conditions for ecesis, its introduced flora is still limited to the single species *Poa compressa*.

The same feature is again illustrated around Bryant's resort on the south shore of the lake. At the small hotel, where all wagon traffic ends, 19 species occurred in 1914 and 29 in 1917. Of the older flora, *Polygonum persicaria*, *Chenopodium hybridum*, *Amaranthus retroflexus*, and *Anthemis cotula* have disappeared, and 14 new species have appeared. These are *Ambrosia artemisiifolia*, *Brassica alba*, *Capsella bursa-pastoris*, *Cerastium vulgatum*, *Chrysanthemum Leucanthemum*, *Galeopsis Tetrahit*, *Lychnis alba*, *Polygonum erectum*, *Rumex obtusifolius*, *Sedum acre*, *Sisymbrium altissimum*, *Trifolium repens*, *Verbascum Thapsus*, and *Veronica arvensis*. Of these new arrivals, *Capsella*, *Cerastium*, *Verbascum*, and *Trifolium* occurred in 1914 around cottages near the hotel and only a minor extension of range has been required. At the same time *Chrysanthemum* and *Sisymbrium* occurred along the main road leading to the hotel and less than a mile away. There still remain eight species which did not occur in the vicinity in 1914, and which have since effected a considerable migration.

In the dooryards of the cottages adjacent to the hotel, 16 species now occur where 13 were living in 1914. *Chenopodium album*, *Trifolium hybridum*, and *Verbascum Thapsus* of the older list have disappeared, while *Capsella Bursa-pastoris*, *Dactylis glomerata*, *Poa annua*, *Polygonum aviculare*, *Sisymbrium altissimum*, and *Trifolium pratense* have appeared. *Dactylis glomerata* did not occur in the vicinity in 1914; all the others were found in the immediate vicinity or along the main road leading to this summer resort.

Around the three cottages farthest from the hotel, 7 species occurred in 1914 and 13 in 1917. None of the earlier list has

disappeared, and 6 have immigrated in three years. These are *Arenaria serpyllifolia*, *Dactylis glomerata*, *Phleum pratense*, *Lepidium virginicum*, *Rumex acetosella*, and *Trifolium repens*. *Arenaria* is the only one of these which does not occur elsewhere in the immediate vicinity.

In the small dooryard of an abandoned Indian hut, where 15 species occurred in 1914, the number has been reduced to 9. No new species has been added, while *Achillea millefolium*, *Chenopodium album*, *Dianthus barbatus*, *Lepidium virginicum*, *Rumex acetosella* and *Trifolium pratense* have disappeared.

On the grounds of the biological station 21 species were reported in 1914, while only 13 occurred in 1917. This involves no new additions, but the loss of eight species: *Avena sativa*, *Brassica arvensis*, *Polygonum Convolvulus*, *Secale cereale*, *Setaria viridis*, *Silene noctiflora*, *Trifolium pratense*, and *Verbascum Thapsus*.

The greatest change in the flora was observed in an isolated clearing in a cedar swamp, occupied by an old man throughout the year, and by one family during the summer months only. Nine of the 24 species listed there in 1914 have disappeared, while 17 species have immigrated. In 1914, 5 of the species were not known elsewhere in the uncultivated region; these have all disappeared. Of the new immigrants, *Melilotus alba*, *Polygonum pennsylvanicum*, and *Satureja acinos* are not now reported from any other stations within the area.

All of these several stations show as before the close dependence of introduced species on human activities. They also indicate a considerable fluctuation in the flora from year to year, involving the loss of some and the addition of other species. In general, the additions are greater than the losses, showing the cumulative effect of intercourse with the villages and agricultural districts on both sides.

A number of causes might be mentioned as possibly contributing to the loss of species, such as hoeing, mowing, or grazing at critical periods in the development of the plants, unfavorable climate, or competition with other species. Continuous observation throughout the season would be necessary to verify any

of these. It is also impossible to describe the exact means of immigration, except in a few special cases, to be mentioned later.

## II. THE INTRODUCED FLORA OF THE ASPENS

In the uncultivated aspen region, covering some ten square miles on the south side of Douglas Lake and not interrupted by farms, the introduced species still occur chiefly along the roadsides. Quantitative studies similar to those of 1914 were made again in 1917, and the quadrats were located not only in the same general region, but almost precisely in the same position. In each of one hundred locations along the state road a strip of 2-meter quadrats was observed, beginning at the wheel track and extending at right angles to the road into the aspens until two successive quadrats without introduced species were reached. In the table, the figures of the first column indicate the number of first quadrats (*i. e.*, adjacent to the wheel track) in which the species was observed, those of the second column the number of second quadrats, and so on.

The close dependence of the introduced species upon the immediate proximity of the roadside is still clearly shown. Nevertheless, the species have extended into the aspens conspicuously

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<i>Poa pratensis</i> .....	76	37	29	22	20	14	10	6	3	3	3	3	4	2	1	1	1
<i>Poa compressa</i> .....	57	36	28	20	19	7	6	4	2	2	1	2	3	1			
<i>Agrostis alba</i> .....	42	5	1	2	6	4	3	3	1	1		1					
<i>Phleum pratense</i> .....	26	6	3	1	1			1									
<i>Trifolium pratense</i> .....	23	6	2		1	1	1		1								
<i>Trifolium repens</i> .....	17	3	1	1	3		1	1									
<i>Trifolium hybridum</i> .....	9	2	1	1													
<i>Rumex acetosella</i> .....	3	7	7	8	10	6	6	5	4	3	1	1	2	1			
<i>Lepidium virginicum</i> .....	4	4	3	2		1	1	1									
<i>Veybasum Thapsus</i> .....		2		2	1	2											
<i>Achillea millefolium</i> .....	2			1													
<i>Agropyron repens</i> .....					1	1	1	1									
<i>Dactylis glomerata</i> .....	1																
<i>Erigeron strigosus</i> .....				1													
Total .....	260	108	75	61	62	36	29	22	11	9	5	7	9	4	1	1	1

beyond their 1914 limits. At that time none was found more than 20 meters (10 quadrats) from the roadway, while in 1917 they extended as far as the seventeenth quadrat, or 34 meters.

This extension of range seems to be due to actual migration of the species concerned, rather than to any space-variation in the local environmental conditions. Most of the introduced species are typically sun plants and never occur under the deep shade of the aspen thickets. The annual growth of the thickets therefore normally tends to reduce the opportunity for their development. Since the aspen seeds germinate poorly except under the peculiar conditions immediately following a fire, new thickets are seldom formed and wide treeless expanses of *Pteris aquilina* occur everywhere in the association. The presence of such treeless areas bears no relation to the penetration of introduced species, and such areas may occur adjacent to the roadside and yet be virtually devoid of all foreign plants.

Immigration of introduced species certainly takes place every year: ecesis only when and where local conditions are favorable. The spring and early summer of 1916 and 1917 were both unusually cool and rainy. Under such conditions the surface layers of sand keep moist for a longer time and afford a better opportunity for seed germination. The extension of range shown by the table may be accounted for by this climatic feature. Even at the present time the number of individuals in the further quadrats is small, while the great mass of plants occurs in the first quadrat, adjacent to the wheel track.

Although many of the species are perennial, their presence seems to be frequently due to repeated immigration, rather than to their own reproduction. Such hardy species as *Achillea millefolium* and *Chrysanthemum Leucanthemum* did not occur in 1917 in stations where they had bloomed in 1915, and their reappearance awaits the coincidence of favorable environmental conditions and new immigration.

### III. THE INTRODUCED FLORA OF HARDWOOD CLEARINGS

There are still some small areas of beech-maple hardwoods being cut for lumber. All the supplies of hay and grain for the lumber camps are hauled in by team, so that there is an exceptionally favorable opportunity for the immigration of seeds of many foreign species. The chance of their germination and

growth is also good, since the ground is covered with leaf mold and is more retentive of moisture than the sand of the aspen association. Nevertheless, the migration of the invaders is closely dependent on human agency, and with one exception the foreign species are not found away from the logging roads which ramify through the forest. This exception is *Hieracium aurantiacum*, which is unusually mobile and is occasionally found at some distance from a road.

Lumbering is in progress during the winter, and the following summer a considerable population of introduced species marks every roadside, and is especially luxuriant in and near the logging camp and stables. One tract of eighty acres, lumbered during the winter of 1914-15, showed 41 introduced species in August, 1915, together with 12 native species, characteristic of clearings and burns. By 1917, 16 of these had disappeared and 11 others had arrived, leaving an introduced flora of 36 species, as listed below. Species common to both years:

<i>Achillea millefolium</i>	<i>Phleum pratense</i>
<i>Agrostis alba</i>	<i>Plantago major</i>
<i>Brassica alba</i>	<i>Poa annua</i>
<i>Capsella bursa-pastoris</i>	<i>Poa compressa</i>
<i>Cerastium vulgatum</i>	<i>Poa pratensis</i>
<i>Chenopodium album</i>	<i>Rumex acetosella</i>
<i>Cirsium arvense</i>	<i>Rumex elongatus</i>
<i>Cirsium lanceolatum</i>	<i>Taraxacum officinale</i>
<i>Cynoglossum officinale</i>	<i>Trifolium hybridum</i>
<i>Echinochloa Crus-galli</i>	<i>Trifolium pratense</i>
<i>Lepidium virginicum</i>	<i>Trifolium repens</i>
<i>Lychnis alba</i>	<i>Verbascum thapsus</i>
<i>Nepeta Cataria</i>	

Species occurring in 1915 only:

<i>Amaranthus graecizans</i>	<i>Polygonum Convolvulus</i>
<i>Amaranthus retroflexus</i>	<i>Polygonum Persicaria</i>
<i>Ambrosia artemisiifolia</i>	<i>Setaria glauca</i>
<i>Anthemis cotula</i>	<i>Silene noctiflora</i>
<i>Avena sativa</i>	<i>Sisymbrium officinale</i>
<i>Hieracium aurantiacum</i>	<i>Solanum nigrum</i>

*Lappula deflexa**Polygonum aviculare**Sonchus asper**Zea Mais*

Species occurring in 1917 only:

*Arctium minus**Arenaria serpyllifolia**Brassica juncea**Chrysanthemum Leucanthemum**Dactylis glomerata**Hordeum jubatum**Ranunculus acris**Sisymbrium altissimum**Veronica arvensis**Veronica peregrina**Vicia villosa*

Besides the change in the flora, still more striking developments were exhibited in the general appearance of the tract. In 1915 the introduced species occurred as numerous but scattered individuals only. In 1917 the premises of the camp and all the logging roads were occupied by a meadow, in which *Poa pratensis*, *Phleum pratense* and *Agrostis alba* were the dominant species, with merely scattered colonies of other species. There were numerous other individuals of introduced species along the walls of the houses, at the edge of sawdust piles, and on rubbish heaps, but the majority of foreign species were limited to a small number of individuals scattered widely through the grass.

It was indicated in the 1914 paper that introduced species are characteristic of the logging roads for several years after they have been abandoned. Their number is gradually reduced as the growth of shrubs and young trees excludes the full sunlight. But if the roads are used by farm wagons, thereby affording continual opportunities for fresh immigration, a foreign flora will occur even in deep shade of the second-growth forest.

#### IV. METHOD OF IMMIGRATION

In general, the immigration of all the introduced species depends upon some form of human activities. The exceptions are *Verbascum Thapsus*, *Lepidium virginicum*, and *Rumex acetosella*, which show some tendency to establish themselves among the aspens at a distance from the roadsides, and *Hieracium aurantiacum*, scattered colonies of which occur in moist ground.

Travel in the uncultivated region is light, and limited almost entirely to wagons. Dung from the horses is dropped along the

roads and several species are known to germinate from undigested seeds. Among these are *Polygonum Convolvulus*, *Chenopodium album*, *Trifolium repens*, *T. pratense*, and *T. hybridum*. Doubtless other species are brought in by the same means. Numerous fishing parties visit the region from the farming land around it, carrying in the wagon bed hay or grain for the horses, and seeds are scattered all along the way. Mud containing seeds may adhere to tires or horses, and drop off later. Certainly various other means exist also, although they have not been seen in operation.

A new cook-house was built for the biological station in 1914, and its premises showed only native species in 1914. Two or three farm wagons stop daily with supplies, and through their agency seven introduced species have arrived in three years. These are *Agrostis alba*, *Capsella Bursa-pastoris*, *Lepidium virginicum*, *Phleum pratense*, *Poa pratensis*, *Rumex acetosella*, and *Taraxacum officinale*.

#### V. NOTES ON INDIVIDUAL SPECIES

During the first few years after the establishment of the biological station, *Lychnis alba* was by no means a common plant. It was not listed by Gates in 1911,\* and was first noted by the writer in one locality in 1912. Since then it has spread rapidly and widely, and is now abundant along most country roads, except in the aspen region, in old logging camps and along logging roads, and in the few cultivated fields near the lake. So continued a migration over such diverse habitats leads to the conclusion that it is actually of recent appearance, rather than that it had been limited in the past because of unfavorable climatic conditions.

Just the reverse is true of *Lappula deflexa*. Noted by Gates in one station only in 1911, it appeared very commonly in the same region in 1914, while in 1917 it had almost completely disappeared. It was completely lacking in some fields where it had been one of the commonest weeds in 1914, and did not appear in

\* F. C. Gates, The vegetation of the region in the vicinity of Douglas Lake, Cheboygan county, Michigan, 1911. 14th Rep. Mich. Acad. Sci. 3: 46-106. 1912.



any of the lists made by the writer for this paper. Since most of its former stations were in exactly the same condition in 1917 as in former years, one can only conclude that the peculiar climatic conditions of 1916 and 1917 are in large measure responsible for its disappearance.

Another similar case is that of *Verbascum Thapsus*. This plant was noted in 1914 as one of the three introduced species which were able to invade the aspen association successfully. In 1917 it was rare in the aspens, and in some particular stations where it had been unusually abundant only dead flowering stems remained. Its seeds are occasionally distributed by water. Seeds lodged in debris on the north shore of Douglas Lake produced flowering stems in 1914, and a number of rosettes were found in the vicinity in 1915. Of these apparently only one came to maturity in 1916. Its dead stem, with a few seeds still in the capsules, was standing in 1917, but no young plants had developed from it.

Two colonies of *Malva moschata* have been known in the vicinity for several years. One of these, along a roadside in clay soil, still persists, while the other, growing in sand, disappeared between 1915 and 1917.

The dispersal of *Sedum acre* is of some interest. It has escaped from cultivation freely along the streets and on the vacant lots of the village of Levering, five miles northwest of Douglas Lake. Its seeds are probably carried from there in mud on tires or on the feet of horses. At Ingleside horses are frequently cleaned or watered in the lake, and the seeds are carried east and established along the shore. One such colony has persisted since 1911, and another was established a mile farther on in 1916.

From a consideration of these few species, and of the general distribution of other foreign species in the region, one is impressed with the precarious existence which most of these plants lead. They appear or disappear, are common or rare, depending upon the chance of migration and upon the yearly fluctuations of climate, while the rapidity with which they migrate or increase in number must be related to the great seed production so characteristic of our introduced weeds.